SUPPLEMENTARY MATERIAL FOR: DO EMISSIONS AND INCOME HAVE A COMMON TREND? A COUNTRY-SPECIFIC, TIME-SERIES, GLOBAL ANALYSIS, 1970-2008

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Dataset. Data sources are the following:

- GDP: Penn World Table (PWT 7.0), see Heston, Summers and Aten (2011), using series rgdpl (PPP Converted GDP Per Capita - Laspeyres, derived from growth rates of c, g, i, at 2005 constant prices), accessed on 12/7/2010.
- Population: UNSTAT, `http://unstats.un.org/unsd/snaama/selbasicFast.asp`, accessed on 12/7/2010.
- Emissions: 'The applied Emissions Database for Global Atmospheric Research', version v4.2 (EDGARv4.2), see `http://edgar.jrc.ec.europa.eu`, Janssens-Maenhout et al. (2013) and the brief description below.

The Emissions Database for Global Atmospheric Research (EDGARv4) is the result of almost 20 years experience with bottom-up emission inventories, driven by the development of scientific knowledge on emission

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CO_2	1970	2000	2008
agriculture/land-use related	24.06%	17.65%	14.65%
products & processes related	4.39%	5.14%	6.03%
energy/fossil fuel related	71.54%	77.22%	79.32%
SO_2			
agriculture/land-use related	2.13%	1.83%	1.93%
products & processes related	16.28%	12.17%	13.23%
energy/fossil fuel related	81.59%	86.01%	84.82%
GWP			
agriculture/land-use related	34.01%	26.40%	22.98%
products & processes related	7.79%	8.95%	9.85%
energy/fossil fuel related	58.20%	64.65%	67.18%

TABLE 1
Shares of activities for different chemical compounds.

generating processes and the scientists' and policy-makers' need for more recent information. The EDGARv4 incorporates a full differentiation of anthropogenic greenhouse gas and air pollutant emissions sources by sector: stationary combustion, road and non-road transportation, fugitive emissions from fuels, industrial non-combustion processes, solvent and other product use, agriculture, soils (a.o. rice cultivation, drained peatlands) and large-scale biomass burning and waste.

The emissions are modelled based on latest scientific knowledge, available global statistics, and methods recommended by IPCC. Official data submitted by the Annex I countries to the UNFCCC and to the Kyoto Protocol are used to some extent, especially regarding the control measures implemented since 1990 that are not available from international statistics. However, the emissions reported by countries are not used entirely because of the prerequisite of cross-country consistency and impartiality. For the recent years the impact of UNFCCC's Clean Development Mechanisms in developing countries to reduce GHG emissions from sources such as coal mines and landfills (CH4), nitric acid and adipid acid production (N2O) and the production of HCFC-22 (HFC-23) is included.

Emissions (EM) for a country c, compound x and year y are computed as

$$EM_c(y,x) = \sum_{i,j,k} \left[AD_{c,i}(y) \cdot T_{c,i,j}(y) \cdot EOP_{c,i,j,k}(y) \cdot EF_{c,i,j}(y,x) \cdot (1 - RED_{c,i,j,k}(y,x))\right]$$

where i indexes sectors within country, j indexes technologies within sector, k indexes abatement measures within technology and the following definitions apply:

- AD: activity data
- T: technology mix factors
- EOP: end-of-pipe reduction factors
- EF: (uncontrolled) emission factors
- RED: relative reduction of the uncontrolled emission by other installed abatement measure

AD data for energy-related sectors is taken from the full IEA 2009 database, and AD data for agriculture-related sectors is taken from the FAO 2010 database.

Historical trends (1970-2008) of sector-specific activity data are given for each of the currently existing countries. The historical statistical data is subdivided to current countries in case of a country breakdown. Special attention had to be given to the industrial processes sector of the countries with Economies In Transition, in particular to former USSR and former Yugoslavia, to match the older totals for the former countries. Statistical data of microstates are often merged with the major neighborhood country (e.g. Monaco and France), along the structure of international statistics.

The technology mixes (such as share of different combustion technologies in the power-plant sector, or the fleet composition in the road transport sector), (uncontrolled) emission factors and end-of-pipe measures, are determined at different levels: country-specific, regional, country group (e.g Annex I/ Non-Annex I), or global. Other abatement measures, in particular CH4 recovery e.g. of coal mining, are determined as total gain at country level using national statistics, and in particular the national inventory reports 2008 of the Parties to UNFCCC. For those source categories and compounds where the different technologies and end-of-pipe measures are needed but can not be detailed, standard regional emission factors represent the typical technology mix. Annex 1 in Janssens-Maenhout et al. (2013) provides all details of the data sources used for the various sectors with specification of the references for the activity data, emission factors, and technologies with abatement measures.

The shares of activities for different emissions of chemical compounds are given in Table 1. The EDGAR dataset has been analysed and compared with national estimates and with other global datasets in Olivier and van Aardenne (2007), Galeotti, Lanza and Pauli (2006), and Hof and Den Elzen (2010).

The data can be downloaded from the following url:
`http://eco.uninsubria.it/webdocenti/pparuolo/pubblicazioni/pub.htm`

Additional tables. We use the approximation based on the gamma distribution proposed by Boswijk and Doornik (2005) for the limit distribution of $LR(j|n)$. The number of steps in the random walks that approximate the Brownian motions was set equal to the effective sample size.

	GWP		SO_2		CO_2	
$H(r)$	$r = 0$	$r \leq 1$	$r = 0$	$r \leq 1$	$r = 0$	$r \leq 1$
Australia	0.659	0.693	0.058	0.406	0.306	0.542
Austria	0.008	0.183	0.013	0.177	0.008	0.204
Belgium	0.087	0.514	0.004	0.014	0.109	0.694
Canada	0.222	0.505	0.054	0.148	0.305	0.562
Denmark	0.186	0.265	0.291	0.559	0.144	0.217
Finland	0.011	0.166	0.006	0.037	0.015	0.153
France	0.140	0.551	0.132	0.710	0.126	0.490
Greece	0.000	0.024	0.001	0.179	0.000	0.013
Iceland	0.656	0.750	0.139	0.587	0.834	0.615
Ireland	0.001	0.383	0.115	0.402	0.022	0.393
Italy	0.067	0.593	0.436	0.654	0.079	0.637
Japan	0.220	0.719	0.350	0.832	0.281	0.846
Luxembourg	0.613	0.488	0.552	0.748	0.664	0.501
Netherlands	0.129	0.298	0.016	0.364	0.135	0.337
New Zealand	0.628	0.775	0.043	0.422	0.506	0.800
Norway	0.302	0.493	0.091	0.635	0.274	0.340
Portugal	0.001	0.930	0.006	0.071	0.001	0.854
Spain	0.002	0.052	0.000	0.003	0.001	0.025
Sweden	0.530	0.588	0.203	0.177	0.475	0.552
Switzerland	0.426	0.838	0.014	0.040	0.006	0.054
Turkey	0.002	0.095	0.015	0.055	0.091	0.159
United Kingdom	0.239	0.575	0.202	0.576	0.071	0.125
United States	0.023	0.664	0.001	0.011	0.030	0.750

TABLE 2

LR trace test p-values Annex I countries in BCK. The p-values were approximated using the technique proposed in Boswijk and Doornik (2005).

	GWP		SO_2		CO_2	
$H(r)$	$r = 0$	$r \leq 1$	$r = 0$	$r \leq 1$	$r = 0$	$r \leq 1$
Argentina	0.395	0.787	0.697	0.673	0.185	0.656
Bolivia	0.552	0.769	0.827	0.826	0.757	0.925
Brazil	0.156	0.536	0.022	0.923	0.110	0.451
Chile	0.014	0.194	0.065	0.070	0.034	0.147
China	0.179	0.577	0.288	0.746	0.198	0.651
Colombia	0.577	0.730	0.826	0.969	0.576	0.604
Costa Rica	0.150	0.356	0.289	0.602	0.794	0.878
Ecuador	0.006	0.718	0.026	0.202	0.009	0.390
El Salvador	0.066	0.136	0.015	0.354	0.574	0.833
Guatemala	0.101	0.100	0.151	0.360	0.026	0.124
Honduras	0.197	0.705	0.410	0.662	0.435	0.631
India	0.344	0.877	0.320	0.865	0.194	0.589
Indonesia	0.391	0.400	0.177	0.267	0.286	0.458
Israel	0.315	0.963	0.188	0.274	0.365	0.959
Jordan	0.002	0.539	0.037	0.429	0.001	0.593
Korea, Republic of	0.148	0.722	0.014	0.818	0.093	0.817
Mexico	0.496	0.307	0.001	0.205	0.020	0.191
Nicaragua	0.812	0.753	0.788	0.792	0.008	0.382
Panama	0.824	0.756	0.791	0.733	0.851	0.775
Paraguay	0.183	0.256	0.488	0.759	0.510	0.826
Peru	0.070	0.223	0.676	0.760	0.794	0.729
Philippines	0.399	0.306	0.700	0.928	0.647	0.714
Singapore	0.031	0.756	0.060	0.180	0.002	0.697
Sri Lanka	0.540	0.704	0.670	0.745	0.774	0.696
Thailand	0.032	0.285	0.079	0.128	0.355	0.365
Uruguay	0.034	0.096	0.015	0.061	0.066	0.496
Venezuela	0.177	0.519	0.493	0.448	0.156	0.426

TABLE 3
LR trace test p-values non-Annex I countries in BCK.

	GWP		SO_2		CO_2	
$H(r)$	$r=0$	$r \leq 1$	$r=0$	$r \leq 1$	$r=0$	$r \leq 1$
Australia	12.0	3.8	22.1	5.8	16.2	4.8
Austria	27.6	8.0	26.3	8.1	27.6	7.7
Belgium	20.8	5.0	29.7	13.8	20.1	3.8
Canada	17.5	5.0	22.3	8.5	16.2	4.7
Denmark	18.2	7.0	16.4	4.7	19.1	7.6
Finland	26.9	8.3	28.4	11.8	26.1	8.5
France	19.2	4.7	19.4	3.7	19.6	5.1
Greece	38.2	12.7	32.0	8.1	39.2	14.0
Iceland	12.0	3.4	19.2	4.5	9.8	4.3
Ireland	34.2	5.9	19.9	5.8	24.9	5.9
Italy	21.6	4.5	14.5	4.1	21.2	4.2
Japan	17.5	3.6	15.6	2.9	16.5	2.8
Luxembourg	12.5	5.2	13.2	3.4	11.9	5.1
Netherlands	19.5	6.7	25.8	6.1	19.4	6.3
New Zealand	12.3	3.3	23.0	5.6	13.7	3.1
Norway	16.2	5.1	20.7	4.2	16.6	6.3
Portugal	32.0	2.0	28.6	10.3	31.8	2.7
Spain	31.3	11.0	38.6	16.9	33.2	12.6
Sweden	13.4	4.5	17.9	8.1	14.0	4.7
Switzerland	14.6	2.8	26.1	11.6	28.3	10.9
Turkey	31.6	9.6	26.0	10.9	20.7	8.4
United Kingdom	17.2	4.6	17.9	4.6	21.5	9.0
United States	24.8	4.0	32.6	14.3	24.0	3.4

Table 4
LR trace test Annex I countries in BCK.

	GWP		SO_2		CO_2	
$H(r)$	$r = 0$	$r \leq 1$	$r = 0$	$r \leq 1$	$r = 0$	$r \leq 1$
Argentina	15.0	3.2	11.6	3.9	18.2	4.0
Bolivia	13.2	3.3	9.9	2.9	10.9	2.1
Brazil	18.8	4.8	24.9	2.1	20.0	5.4
Chile	26.1	7.9	21.7	10.3	23.7	8.6
China	18.3	4.6	16.4	3.5	18.0	4.1
Colombia	12.9	3.6	10.0	1.5	12.9	4.4
Costa Rica	19.0	6.2	16.4	4.4	10.4	2.5
Ecuador	28.4	3.6	24.5	7.8	27.4	5.9
El Salvador	21.6	8.7	25.8	6.2	12.9	2.9
Guatemala	20.3	9.5	19.0	6.1	24.5	9.0
Honduras	18.0	3.7	14.8	4.0	14.5	4.2
India	15.6	2.5	16.0	2.6	18.0	4.5
Indonesia	15.0	5.8	18.4	7.0	16.5	5.4
Israel	16.0	1.6	18.1	6.9	15.4	1.7
Jordan	30.5	4.8	23.5	5.6	32.9	4.5
Korea, Republic of	19.0	3.6	26.1	3.0	20.6	3.0
Mexico	13.8	6.6	33.9	7.7	25.2	7.9
Nicaragua	10.2	3.4	10.5	3.2	27.5	5.9
Panama	10.0	3.4	10.4	3.5	9.6	3.3
Paraguay	18.3	7.1	13.9	3.4	13.7	2.9
Peru	21.4	7.5	11.8	3.4	10.4	3.6
Philippines	15.0	6.6	11.5	2.0	12.1	3.7
Singapore	23.9	3.4	22.0	8.0	30.9	3.8
Sri Lanka	13.3	3.7	11.9	3.5	10.7	3.8
Thailand	23.9	6.8	21.1	8.9	15.5	6.1
Uruguay	23.7	9.6	26.0	10.7	21.7	5.1
Venezuela	18.4	4.9	13.8	5.5	18.8	5.6

TABLE 5

LR trace test non-Annex I countries in BCK

	GWP			SO_2			CO_2			GDP
	β_1	β_2	β_D	β_1	β_2	β_D	β_1	β_2	β_D	average
Australia										10.18
Austria	0	-1	0.02	0	-1	0.02	0	-1	0.02	10.17
Belgium										10.12
Canada										10.20
Denmark										10.16
Finland	-1	-0.85	0.02				-1	-1.22	0.03	10
France										10.08
Greece				-1	-0.86	0				9.82
Iceland										10.19
Ireland	-1	-0.32	0.02				-1	0	0.01	9.83
Italy										10.03
Japan										10.07
Luxembourg										10.61
Netherlands				-1	-4.23	0				10.19
New Zealand				-1	1.98	-0.08				9.93
Norway										10.37
Portugal	-1	2.42	-0.04	-1	-3.42	0.11	-1	3.43	-0.06	9.51
Spain	0	-1	0.02							9.86
Sweden										10.15
Switzerland							-1	0	-0	10.38
Turkey	-1	0.83	0	-1	0	0				8.81
United Kingdom										10.07
United States	0	-1	0.02				0	-1	0.02	10.32

Table 6

Estimates of β when the selected cointegration rank r is equal 1; Annex I countries in BCK.

	GWP			SO_2			CO_2			GDP
	β_1	β_2	β_D	β_1	β_2	β_D	β_1	β_2	β_D	average
Argentina										9.05
Bolivia										8.04
Brazil				-1	-1.55	0				8.77
Chile	-1	1.98	-0.05				-1	1.96	-0.04	8.76
China										7.30
Colombia										8.46
Costa Rica										9
Ecuador	-1	0	0.01	-1	0	0	-1	0	0.02	8.51
El Salvador				-1	5.17	-0.02				8.47
Guatemala							-1	4.55	0	8.54
Honduras										8.03
India										7.23
Indonesia										7.66
Israel										9.82
Jordan	-1	1.48	0	0	-1	0.04	-1	1.58	0	8.26
Korea, Republic of				-1	4.38	-0.26				9.18
Mexico				0	-1	0	-1	0	0	9.11
Nicaragua							0	-1	-0.02	7.87
Panama										8.65
Paraguay										8.10
Peru										8.55
Philippines										7.65
Singapore	-1	3.11	-0.11				-1	3.46	-0.13	9.95
Sri Lanka										7.56
Thailand	0	-1	0.04							8.24
Uruguay	0	-1	0.02	0	-1	0.02				8.80
Venezuela										9.09

TABLE 7
Estimates of β when the selected cointegration rank r is equal 1; non-Annex I countries in BCK.

	GWP		SO_2		CO_2	
	W_1^{Δ}	W_2^{Δ}	W_1^{Δ}	W_2^{Δ}	W_1^{Δ}	W_2^{Δ}
Australia	0	1	0	1	0	1
Austria						
Belgium	0	1			0	1
Canada	0	1	0	0	0	1
Denmark	0	1	0	1	0	1
Finland						
France	0	1	0	1	0	1
Greece						
Iceland	0	1	0	1	0	1
Ireland			0	1		
Italy	0	1	0	1	0	1
Japan	1	1	0	0	1	1
Luxembourg	0	1	0	1	0	1
Netherlands	0	1			0	1
New Zealand	1	1			0	1
Norway	0	1	0	1	0	1
Portugal						
Spain						
Sweden	0	1	0	1	0	1
Switzerland	0	1				
Turkey					0	1
United Kingdom	1	0	0	1	1	1
United States						

TABLE 8

Granger non causality tests for $r = 0$, Annex I countries in BCK. Entries equal to 0 indicate insignificant statistics, entries equal to 1 significant statistics at $\gamma = 0.05$ level. W_1^{Δ} tests the hypothesis that income does not Granger-cause emissions in growth rates. W_2^{Δ} tests the hypothesis that emissions do not Granger-cause income in growth rates.

	GWP		SO_2		CO_2	
	W_1^Δ	W_2^Δ	W_1^Δ	W_2^Δ	W_1^Δ	W_2^Δ
Argentina	0	0	0	0	0	0
Bolivia	0	0	0	0	0	0
Brazil	0	0			1	0
Chile			1	0		
China	1	1	1	1	1	1
Colombia	0	1	0	1	0	1
Costa Rica	0	0	1	0	0	0
Ecuador						
El Salvador	0	1			0	0
Guatemala	0	0	0	0		
Honduras	0	0	0	0	0	0
India	0	1	0	1	0	1
Indonesia	0	1	0	1	0	1
Israel	0	1	0	1	0	1
Jordan						
Korea, Republic of	0	1			0	1
Mexico	0	1				
Nicaragua	0	0	0	0		
Panama	0	1	1	1	0	1
Paraguay	0	0	0	0	0	0
Peru	0	1	0	0	0	0
Philippines	0	0	0	0	0	0
Singapore			0	1		
Sri Lanka	0	1	0	1	0	1
Thailand			1	1	0	1
Uruguay					0	0
Venezuela	0	0	0	0	0	0

Table 9

Granger non causality tests for $r = 0$, non-Annex I countries in BCK. Entries equal to 0 indicate insignificant statistics, entries equal to 1 significant statistics at $\gamma = 0.05$ level. W_1^Δ tests the hypothesis that income does not Granger-cause emissions in growth rates. W_2^Δ tests the hypothesis that emissions do not Granger-cause income in growth rates.

	GWP						SO_2						CO_2					
	t_1	t_2	W_1^Δ	W_2^Δ	W_1	W_2	t_1	t_2	W_1^Δ	W_2^Δ	W_1	W_2	t_1	t_2	W_1^Δ	W_2^Δ	W_1	W_2
Australia																		
Austria	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
Belgium																		
Canada																		
Denmark																		
Finland	1	1	0	1	1	1							1	1	0	1	1	1
France																		
Greece							1	0	0	0	1	1						
Iceland																		
Ireland	1	0	1	0	1	0							1	0	0	0	1	0
Italy																		
Japan																		
Luxembourg																		
Netherlands							0	1	0	1	0	1						
New Zealand							1	0	0	0	1	0						
Norway																		
Portugal	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
Spain	0	1	0	1	0	1												
Sweden																		
Switzerland													1	0	0	0	1	1
Turkey	1	0	0	0	1	1	1	0	0	0	1	1						
United Kingdom																		
United States	1	1	0	1	0	1							1	1	0	1	0	1

TABLE 10

Granger non causality tests for $r = 1$, Annex I countries in BCK. Entries equal to 0 indicate insignificant statistics, entries equal to 1 significant statistics at $\gamma = 0.05$ level. t_1, W_1^Δ, W_1 are tests of hypotheses that income does not Granger-cause emissions. t_2, W_2^Δ, W_2 are tests of hypotheses that emissions do not Granger-cause income.

	GWP						SO_2						CO_2					
	t_1	t_2	W_1^Δ	W_2^Δ	W_1	W_2	t_1	t_2	W_1^Δ	W_2^Δ	W_1	W_2	t_1	t_2	W_1^Δ	W_2^Δ	W_1	W_2
Argentina																		
Bolivia																		
Brazil							1	1	1	1	1	1						
Chile	0	1	1	1	0	1							0	1	0	1	0	1
China																		
Colombia																		
Costa Rica																		
Ecuador	1	1	1	1	1	1	0	1	0	1	0	1	1	1	1	1	1	1
El Salvador							1	1	1	1	1	1						
Guatemala													1	1	0	1	1	1
Honduras																		
India																		
Indonesia																		
Israel																		
Jordan	1	0	0	0	1	0	1	0	0	0	1	0	1	0	0	0	1	0
Korea, Republic of							1	0	0	0	1	1						
Mexico							1	1	1	1	1	1	1	0	1	1	1	1
Nicaragua													1	1	1	1	1	1
Panama																		
Paraguay																		
Peru																		
Philippines																		
Singapore	1	1	0	1	1	1							1	1	0	1	1	1
Sri Lanka																		
Thailand	0	1	0	1	0	1												
Uruguay	0	1	0	1	0	1	0	1	0	1	0	1						
Venezuela																		

TABLE 11

Granger non causality tests for $r = 1$, non-Annex I countries in BCK. Entries equal to 0 indicate insignificant statistics, entries equal to 1 significant statistics at $\gamma = 0.05$ level. t_1, W_1^Δ, W_1 are tests of hypotheses that income does not Granger-cause emissions. t_2, W_2^Δ, W_2 are tests of hypotheses that emissions do not Granger-cause income.

	GWP		SO_2		CO_2	
	W_1^2	W_2^2	W_1^2	W_2^2	W_1^2	W_2^2
Australia						
Austria						
Belgium			0	0		
Canada						
Denmark						
Finland			0	0		
France						
Greece	1	1			1	1
Iceland						
Ireland						
Italy						
Japan						
Luxembourg						
Netherlands						
New Zealand						
Norway						
Portugal						
Spain			1	1	1	1
Sweden						
Switzerland			0	0		
Turkey						
United Kingdom						
United States			0	0		

Table 12

Granger non causality tests for $r = 2$, Annex I countries in BCK. Entries equal to 0 indicate insignificant statistics, entries equal to 1 significant statistics at $\gamma = 0.05$ level. W_1^2 tests the hypothesis that income does not Granger-cause emissions in levels. W_2^2 tests the hypothesis that emissions do not Granger-cause income in levels.

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